Food loss analysis: causes and solutions

Case study on the mango value chain in the Republic of Guyana
Food loss analysis: causes and solutions
Case study on the mango value chain in the Republic of Guyana
Contents

Abbreviations and acronyms  v
Acknowledgements  vi
Executive Summary  vii
Chapter 1  1
Introduction  1
Chapter 2  3
Methodological approach  3
Chapter 3  7
Situation analysis  7
  Relevant institutions  7
  Description of subsector supply chain with gender disaggregated data  8
  Identification of ongoing work  8
  Description of the marketing systems  10
Chapter 4  11
Study findings  11
  Secondary data and key-informant (Expert) interviews  11
  History of government and private sector involvement in the subsector  13
  Inventory of activities and lessons learned from past and ongoing interventions  15
  Current policy framework on subsector food losses  16
  Preliminary analysis of post-harvest losses (screening)  17
Chapter 5  19
Food losses – Study findings and results (survey)  19
  Critical loss points: type and level of food losses  19
  Sample analysis  19
  Causes of losses  19
  Tracing of value added products – kuchelar and frozen slices  23
  Food loss reduction strategies  24
Bibliography  31
TABLES
4.1 Volume of mangoes produced in Guyana (Tonnes): 2007-2012 11
4.2 Volume and value of mango and mango achar exported from Guyana during 2008–2012 12
4.3 Average annual wholesale prices for mangoes (GYD/kg) 12
4.4 Average annual retail prices in GYD/kg 13
4.5 Detailed description of the mango supply chain – West Coast Berbice, Region 5 14
5.1 Quantitative and qualitative losses occurring in the fresh ripe mango cv. Buxton Spice value chain in Guyana 19
5.2 Quality attributes of mango in Guyana 20
5.3 Nature and types of post-harvest losses of fresh ripe mango in Guyana 22
5.4 Nature and post-harvest losses of mango value-added products 24
5.5 Economic loss associated with respective critical loss points – Mango, Guyana 27
5.6 Summary of food losses, causes and solutions – Guyana 27
5.8 Profitability of using a mango picking rod on 5-acres of mangoes in Guyana 28
5.9 Profitability of using a ripening room for 5 acres of mangoes in Guyana 29

FIGURES
1 Post-harvest handling activities at a packinghouse facility at Piarco in Trinidad and Tobago 8
2 Map of Guyana showing the ten administrative regions 9
3 Current non-traditional agriculture produce supply chain 9
4 Mango value chain showing the critical loss points (CLPs) 18
5 Mango kuchelar 20
6 Frozen mango slices 20
7 Harvesting rod with cutting blade and netted pouch 21
8 Various forms of physical damages 21
9 cv. Long with latex stains 21
10 Physiological disorder, internal breakdown 22
11 Anthracnose infections on cv. Julie 23
12 Scale insect damage cv. Long 23
13 Fruit fly infestation cv. Julie 23
14 Mango seed weevil cv. Long 23
15 Internal quality of cv. Long at different stages of maturity 24
16 Internal quality of cv. Julie at different stages of maturity 24
17 Mango in stackable, ventilated plastic crates. 25
18 Preparation of fresh-cut mango slices 25
19 cv. Julie with bird damage 25
Abbreviations and acronyms

ADB    Agricultural Development Bank
ADP    Agricultural Export Diversification Project
CABA   Caribbean Agribusiness Association
CABI   Centre for Agriculture and Bioscience International
CARICOM Caribbean Community
CARIRI Caribbean Industrial Research Institute
CARDI  Caribbean Agricultural Research and Development Institute
CAREC  Caribbean Epidemiology Centre
CHF    Formerly Canadian Hungary Foundation, now CHF–Partners in Rural Development
CLP    Critical Loss Point
CRU    Cocoa Research Unit
FAO    Food and Agricultural Organization of the United Nations
FSC    Food Supply Chain
GAP    Good Agricultural Practices
GDP    Gross Domestic Product
GOG    Government of Guyana
GMPP   Guyana Micro-Projects Programme
GTIS   Guyana Trade and Investment Support
HAACP  Hazard-Analysis and Control of Critical Points
IDB    International Development Bank
IFAD   International Fund for Agricultural Development
IICA   Inter-American Institute for Cooperation on Agriculture
ICTA   Imperial College of Tropical Agriculture
ILO    International Labour Organization
ISHS   International Society of Horticultural Science
NAREI  National Agricultural Research and Extension Institute (Guyana)
NARI   National Agricultural Research Institute
NGMC   New Guyana Marketing Corporation
PRCSSP Poor Rural Communities Support Services Project (Guyana)
READ  Rural Enterprise and Agricultural Development Project (Guyana)
RH     Relative humidity
THA    Tobago House of Assembly
USAID  United States Agency for International Development
UWI    University of the West Indies
Acknowledgements

Authors of this study are Majeed Mohammed and Kelvin Craig. The study was edited by Joseph Mpagalile, FAO and Vyjayanthi Lopez, FAO.

The authors wish to acknowledge the support received from the Representative of the Food and Agriculture Organization of the United Nations (FAO) in Guyana. Also acknowledged is the tremendous dedicated support of the Research Assistant of the National Agricultural Research and Extension Institute (NAREI), and Mr Premdat Beecham, Packaging Facilities Manager of Guyana Marketing Corporation.

The support of the Permanent Secretary, Ministry of Agriculture, Guyana, Mr George Jervis, Chief Executive Officer, NAREI, Dr O. Homenauth, General Manager, New Guyana Marketing Corporation, GMC, is greatly appreciated.

Special gratitude and acknowledgement go to Dr Vyjayanthi Lopez from the FAO Subregional Office for the Caribbean and Dr Joseph Mpagalile from FAO Headquarters in Rome for their support and guidance.

Support from a number of Extension Staff is highly appreciated in Counties Saint George, Caroni, Saint Patrick and Saint David in Trinidad and Tobago; other staff from agencies such as NAMDEVCO and UWI; industry experts; several farmers and farmers’ groups; a number of retailers, intermediaries, wholesalers, exporters, processors, input suppliers, supermarkets and produce associations.
Mango is one of the most important fruits with an estimated global production of about 30 million tonnes in 2010 (FAO, 2010) and it is the second largest tropical fruit crop in the world after banana. More than 70 percent of the fruit is produced in Asia and the Pacific, about 13 percent in Latin America and the Caribbean and less than 10 percent in Africa (Yahia, 2011).

Mango production, however, in Guyana has decreased from 4 200 tonnes in 2007 to about 1 500 tonnes in 2012. Export volume exceeded the 300 tonnes mark during the 2008–2010 period but decreased to 170 and 182 tonnes respectively in 2011 and 2012. New Guyana Marketing Corporation (NGMC) data also shows that relatively small quantities of kuchelar (achar) were exported during the 2007–2012 period. The only exception was in 2011 when 21 tonnes valued at USD 102 000 were exported.

Successful post-harvest handling of mangoes requires knowledge of the post-harvest physiology of the fruit and understanding of how this determines handling practices to maintain quality and develop high quality fruit. The post-harvest handling system used for mangoes also depends on the marketing system in which the fruit will be sold. This includes factors such as distance to the market, the desires and expectations of the consumers in that market, and the availability of labour, technology, logistics management and infrastructure required for various handling options (Yahia, 2011).

Accordingly, successful post-harvest handling of mangoes involves managing the ripening process and avoiding quality losses resulting from physical damage and decay. As mangoes mature on the tree and begin to ripen, eating quality improves but potential marketable life decreases because of the difficulty of controlling the ripening changes once they have been initiated. Throughout the Caribbean, including Guyana, there is a need to develop improved handling, storage and ripening techniques as well as safety so as to promote mango value-added products. Factors relating to causes, types, and magnitude of damage that lead to quality deterioration and post-harvest losses are significant for the growth and development of the mango industry in the Caribbean.

Accordingly, FAO in collaboration with CARICOM initiated a project Reduction of post-harvest losses along the food chain in the CARICOM subregion and identified mango as one of the three commodities for post-harvest loss measurement. The main objectives of the investigation included in-depth analysis of post-harvest handling practices of mango producers, retailers (roadside and mobile market vendors, municipal markets, supermarkets), wholesalers, exporters, processors for development of value-added products and consumers, to obtain a more complete understanding of the system-wide nature of quality deterioration and subsequent losses in order to formulate appropriate solutions for quality management and loss reduction strategies; analysis of the mango value chain as items for food consumption, with quality attributes that must be protected and enhanced in various marketing channels; examination of the significance of losses of both technological and socio-economic origins; examination of the links between growers and provisions for transferring relevant research information on identified problems to producers, traders, processors; design and evaluation of improved operations throughout the system and alternative post-harvest handling systems; and description of key factors affecting the logistics performance in the CARICOM Region with particular emphasis on logistics that affect produce losses in the supply chain.

Post-harvest losses of mangoes were measured at four critical loss points (CLPs) after screening the value chains. The critical loss points were at harvest (CLP#1), development of value added food products such as kuchelar and frozen mango slices (CLP#2 and CLP#3), and display and sale of ripe fruits at retail markets (CLP#4). Total post-harvest losses varied according to cultivar, and the stage in the supply chain. The total post-harvest losses were 28 percent for cv. Buxton Spice in Guyana. Physical damage observed as bruises, compression, stem end damage, punctures, and abrasions, physiological disorders had been caused by heat stress and desiccation and internal breakdown as well as decay caused by fungal and bacterial diseases were prominent for cv. Buxton Spice.
Proposals for the reduction of post-harvest losses of mangoes at CLP#1 include: harvesting at the appropriate stage of maturity to attain the best eating quality; handling mangoes with care in order to minimize fruit damage; protecting harvested mangoes from exposure to direct sunlight while awaiting transport to the packinghouse; preventing latex damage and stains on harvested fruit; and selecting a transport method that allows for ventilation during transit from field to packinghouse.

Further, proposals for the reduction of post-harvest losses of mango at CLP#2 and CLP#3 include: processors stipulating that suppliers sort fruit according to cultivar, size, skin and flesh colour, shape, with minimum physical damage; all cutting tools and utensils should be sanitized and made of stainless steel with sharp cutting edges; cut frozen slices must be washed, rinsed and pre-packaged immediately after cutting to minimize enzymatic browning; the entire processing facility should be sanitized and a low temperature environment should be maintained during all fresh-cut processes in order to reduce potential microbial problems.

Finally, proposals for the reduction of post-harvest losses of mango at CLP#4 include: harvesting only mangoes that are physiologically mature for the ripe table fruit market; capitalizing on market demands by enhancing the ripening process; and implementing a regular cleaning and sanitation programme to maintain quality and attractive display of fruits.

In Guyana, the total economic loss was estimated at USD 786 256. It is important to note, however, that these are estimates only, based on the results of the percentage losses in areas the post-harvest loss assessment studies were carried out.
Chapter 1
Introduction

Background Information
A high incidence of post-harvest losses exacerbates the problems of low agricultural productivity and food security in countries of the Caribbean Community (CARICOM). Post-harvest losses cause the quality and quantity of food to be severely reduced, thereby affecting incomes and impacting on the rural poor in the region. The Food and Agriculture Organization of the United Nations (FAO, 2011) indicated that post-harvest losses are highest in developing countries. Fonseca and Vergara (2014) reported that in the Latin America and Caribbean (LAC) Region 50 percent of the fruits and vegetables and 37 percent of roots and tubers are lost before they reach consumers and it was suggested that improving logistics systems and management would be an efficient approach to reducing losses across the supply chain. It was found that failure in logistics operations including product handling, precooling, packaging, storage, transportation, and inappropriate infrastructure, are among the most common reasons for the high quantities of food losses. These estimates do not include loss of quality, nutritional value and the health burden associated with consuming contaminated food products.

Several factors contribute to post-harvest losses along the supply chain such as preharvest factors, environmental hazards (inadequate temperature and relative humidity control), pests and diseases and senescence. Reducing the incidence of post-harvest losses along the food chain in the CARICOM subregion will contribute to: improving the availability of food to address food insecurity, enhancing food quality (better packaging, handling and storage), increasing economic access to food through job creation and income-generation, development of efficient logistics systems to improve market access by delivering the right product at the right time.

Efforts to combat this situation in the past have not been very successful partly because countries lack the required and up to date information about the scale of the problem that could have helped them develop programmes to address the problem. This lack of reliable and up-to-date information and data has continuously prevented governments, private sector and other key stakeholders from implementing workable solutions. While there is an increasing acknowledgement among governments in the CARICOM Region and the international community that post-harvest loss reduction is one of the principal elements required to reduce food insecurity, use of inappropriate and outdated approaches remains a constraint to current interventions. This rapidly changing context, which is related to such factors as urbanization and globalization, and means that interventions that were regarded as successful in the past may no longer be so. This is causing governments to inadequately tackle the challenges facing the post-harvest sector.

Given the need to better understand the strengths and weaknesses of the post-harvest handling systems in the CARICOM and to identify, plan and implement interventions policies and practices, two countries, Guyana and Trinidad and Tobago were initially identified by the FAO to conduct detailed value chain analyses pertaining to cassava, tomato and mango.

Study objective
The main objective of this study was to conduct an in-depth analysis of the post-harvest handling practices of mango producers, marketers, processors and consumers, to obtain a more complete understanding of the system-wide nature of quality deterioration and subsequent losses in formulate appropriate solutions for quality management and loss reduction strategies. Furthermore, the assessment aimed to identify the critical loss points and causes of losses at these points by using post-harvest loss assessment methodologies and tools.
In addition, a desk research was conducted to identify cost effective, environmentally friendly and gender appropriate solutions to reduce post-harvest losses, drawing on an inventory of past and current technologies and practices within the region and outside the region.
Chapter 2
Methodological approach

Selection of countries and subsectors
CARICOM Member Countries Guyana and Trinidad and Tobago were selected for this study based on the importance of the targeted subsectors: cassava, mango, and tomato. In addition, the assessment was conducted in Saint Lucia, a CARICOM Member Country and a member of the Organization of Eastern Caribbean States (OECS). The study in Saint Lucia was undertaken so as to compare and verify the results obtained in Guyana and Trinidad and Tobago.

Selection of food supply chains
Three subsectors that are important in the CARICOM Region were identified during a preceding study. The identification of these priority crops followed an in-depth desk study to review available information on production, post-harvest handling including processing, marketing, export, etc. for the major food crops in the CARICOM Region. Reports from previous studies conducted by the FAO, CARICOM, regional institutions and other national and international organizations were analysed. Several crops were identified that are important in the agricultural systems in the Region, however, cassava, tomato, and mango emerged as important food value chains and were therefore recommended as the priority crops for the project on the reduction of food loss and waste in the CARICOM Region.

Selection of farmers, supermarkets and other stakeholders
The mango value chain includes a highly diverse and complex number of producers (farmers) and traders (market types: farmer’s or public municipal, roadside, mobile, supermarkets, processors) characterized by widely scattered production areas and fragmented marketing facilities. This structural variety, coupled with widely differing post-harvest practices among participants posed considerable challenges for this investigation, which attempted to understand the entire value chain and its operations. In order to uncover the differences in post-harvest operations among the diverse range of producers and marketers as well as those linked to cultural methods in different locations required of the study, field observations and interviews were of paramount importance. The techniques employed were based on the 4-S approach used by the FAO involving screening, sampling and survey and synthesis.

In Guyana, wholesalers and retailers were randomly selected from Mon Repos Market, Bourda Municipal Market and Stabroek Municipal Market. Also two of the largest supermarkets were visited, Nigel’s and Bounty and one of the smaller ones (Bunny’s). Roadside and mobile markets were selected at random throughout the villages. At each market outlet, every stage that could potentially reduce marketable quality and eventually manifest post-harvest losses, from the field in the case of a producer, or from procurement in the case of a trader to the point of consumer purchase, was selected for in-depth analysis. This approach is referred to as the ‘systems approach’.

Data collection
The methodology used for this study involved a literature review; collection and analysis of the documentation and technical information on mango; selection of the specific supply chains for the study and justification for this choice; identification of 3 to 4 stages of the food chain where the losses are higher, or have the greatest impact and selection of 1 to 2 for detailed analysis; and participation and contribution to the development of a comprehensive approach, including appropriate tools for data collection and analysis identifying the scope and limitations of the study as well as gaps, to ensure that all marketing aspects, including handling and shipping are included. The implementation strategy for this study embraced the Food Loss Assessments methodology recom
mended by the FAO and where necessary adapting it to the Caribbean situation.

**Study approach**

A similar approach was used for cassava, mango and tomato. The study had five main components: **Literature review** of previous studies documented by regional institutions such as the FAO, CARDI, IICA, University of the West Indies, University of Guyana, University of Trinidad and Tobago and other national institutions such as the respective Ministries of Agriculture, Central Marketing Agencies and stakeholders, the Agricultural Society of Trinidad and Tobago, National Food Crops Farmers Association and Trinidad and Tobago Agribusiness Association was undertaken in order to identify the ongoing work in the field of food losses and examine the completeness and gaps.

**Selection of the specific supply chains and the geographical area (countries) of the study and justify the reasons for this choice** – The main actors in the supply chain of each commodity included farmers, processors, retailers, wholesalers, supermarkets and associations. Selection was based on production and marketing volumes from data obtained from the national marketing institutions. A processing company or cottage industry for development of a major value-added product from each commodity in each country was also be included.

**Conducting and managing field interviews** – Approximately 2.5 months were spent in the field for interviews and data collection. In an effort to catalogue all the standard operating practices in the value chain, a set of themes of inquiry was developed to guide the interviewing process and a questionnaire was compiled. Preliminary interviews were used to identify the themes for questioning. All interviewees cooperated, many enthusiastically, when the interview was conducted within their own work environment in a two-way fashion employing the ‘mirror image technique’.

The main elements of the mirror image technique involved: dynamic, face to face interviews revealing an interpersonal process with principal decision-makers associated with production, post-production, processing into value-added products, distribution and marketing functions; the consultants established a rapport with interviewees while marshalling an extensive complex of variables in an intensive environment; the consultants had the flexibility of switching from a non-directive role at the early stages of the interview to a more directive one afterwards; post-harvest practices were examined with respect to each theme of inquiry; perceptions among mango farmers of the possible nature of post-harvest problems in terms of quality changes and losses for the identical theme were examined; automatic checks were established to avoid data collection errors arising from interviewees’ bias, lack of knowledge of the correct answer or deliberate falsification of data by tracing and tracking the original causal factor.

Management of the interviews varied from farmer to trader to processor. While some were located with the assistance of the Agricultural Assistants in the county extension offices of the MFPLMA, others were located using their addresses as they appeared on the list of registered farmers and processors. On several occasions mango farmers were met when attending some of the Agricultural District Meetings. With traders, a combination of methods was used. Supermarket retailers were informed by telephone to alert them of the survey, potential objectives and uses. Interviews with wholesalers, public markets, mobile market and roadside market vendors were completed at the actual location mostly without previous arrangement.

Interviews almost always took place in the midst of the activity characteristic of post-harvest operations. As such the consultants were able to pose questions in the work environment and, in many cases, to actually witness the decision-making of the traders where and when it occurred. This great advantage, however, of being able to observe and record manifest behaviour pertinent to systematic processes was tempered by adherence to the methodology. It was imperative that the consultants remained in an observational role, and did not introduce themselves into the process to the extent that they become a variable thereby altering, even imperceptibly, the true decision-making environment. The consultants and technicians recognized their presence could encourage a typical response. These effects were believed to be minimized by thoroughly cross-checking responses against a wide variety of outlets.

**Identification of 3-4 stages of the food chain(s) where the losses are higher or have the greatest impact and detailed analysis of 1-2** – The Critical Loss Points (CLPs) were identified from observation, the literature review, interviewing of experts, marketing quality assurance officers and field
officers. For each supply chain one value-added product was followed at the particular processing facility be it village industry or larger scale processing company. For each commodity a flow diagram was prepared to pinpoint the critical loss points and this was investigated in detail to identify causes and potential solutions. At least two stages were identified for detailed analysis during the systematic evaluation of losses of the entire post-harvest handling system for each commodity and where there was a potential for post-harvest losses to dominate.

Samples were purchased at each CLP and at the exact location where the activity of that particular stage was observed. Each sampling consisted of three replications of 12 to 15 kg of randomly selected mangoes, which was representative of a market load. Each mango sample was examined for marketable quality on a scale of 1 to 9 based on a method developed by Sherman et al., (1982) with 1= unusable, 3= unsalable, 5= fair (limit to marketability), 7= good and 9= excellent. Following this each mango sample was examined for damage and classified into two broad categories: marketable and unmarketable, based on the severity of damage. The unmarketable mango samples were designated as the post-harvest loss, weighed and the percentage loss calculated against the original weight.

To determine the nature of damage in the unmarketable category, mango samples were further subdivided into three categories according to the nature of the damage apparent at that location, that is, physical, physiological and pathological and entomological. Physical damage included cuts, bruises, punctures, scratches, splits, crushes, abrasions and cracks. Physiological damage included moisture loss (wilting, shrinkage), heat stress and internal breakdown. Pathological and entomological damage included that caused by fungi and bacteria. Fruit fly and mango seed weevil were insect related damages. The weights of each category of damage were recorded and percentage of post-harvest loss calculated for each category. Total post-harvest losses were obtained by summing the losses recorded at each CLP (Figure 1). Mango samples were also taken to the UWI post-harvest laboratory to collect data on fruit dimensions, firmness and total soluble solids.

Description of the principle activities of the study

The flow of mango from the point of harvest to consumption for producers and traders was documented by observing and recording the duration of each component of the system, the time taken for the fruit to move from one component to the next, including delays as well as measurable characteristics of the environment, i.e. temperature, relative humidity and time of day. In addition, hands-on familiarization with the mango handling operations provided the framework for examining typical patterns of decisions and actions taken by participants within the mango value chain. This also provided information on the dynamics of the mango value chain and allowed for its comprehensive mapping. By inserting the stages of the post-harvest handling system for mango within the value chain a template was provided for tracking and tracing and more importantly identification of the CLPs.
Chapter 3
Situation analysis

RELEVANT INSTITUTIONS

Two public agencies are responsible for carrying out activities related to post-harvest handling and are primarily concerned with post-harvest losses in root crops, fruits and vegetables. They both come under the purview of the Ministry of Agriculture and are the National Agricultural Research and Extension Institute (NAREI) and the New Guyana Marketing Corporation (NGMC).

The National Agricultural Research and Extension Institute (NAREI) is the premier Research and Extension Institute in the field crops (excluding rice and sugarcane), fruits and vegetables, biofuels as well as for plant quarantine services. NARI was established 28 years ago, for developing and extending the necessary technology and support services to facilitate national agricultural development. During 2010, with the passing of the new NAREI Act in Parliament, its research and development programmes were re-oriented to keep in view the Acts, national and global changes as well as to promote greater efficiency in the crops and agricultural product industry, to provide enhanced services in agricultural research and extension and crop protection, regulation of trade, commerce and export of crops and agricultural products.

Among its basic functions, NAREI is tasked with advising and developing appropriate systems to promote balanced, diversified and sustained agricultural production through adaptive and investigative research. In addition to broad research and development activities for Guyana’s agricultural sector, NAREI is also responsible for transferring the technology it has developed to farmers, students, extension personnel, etc.

University of the West Indies – This is another important institute in the region. The Faculty of Agriculture at the University of the West Indies, St Augustine Campus has been conducting agricultural research since 1926. Post-harvest studies are currently being pursued in both faculties on innovative methods to reduce losses of tropical commodities and enhancement of value-added products.

The UWI has also conducted several workshops throughout the Caribbean. The Third International Conference on Post-harvest and Quality Management of Horticultural Products of Interest to the Tropical Region was held by UWI in July 2013 in Trinidad under the auspices of the International Society of Horticultural Science (ISHS). The theme was “Post-harvest technological initiatives to improve food security and market access”. A follow-up workshop entitled ‘Post-harvest management strategies to reduce losses of perishable crops’ was held in Trinidad from 24 to 25 February 2014 by UWI/CTA/NAMDEVCO to train certified farmers, exporters and field officers.

New Guyana Marketing Corporation (GMC) is a government corporation that was established in the 1960s as the Guyana Marketing Corporation under Section 46 of the Public Corporations Act, Cap 19:05 of the Laws of Guyana. The Corporation was reorganized in 1985 and its functions include the provision of market facilitation services; the dissemination of post-harvest technology; market research and the provision of market intelligence services.

In addition to the above, the NGMC manages two fresh produce packaging facilities: the Central Packaging Facility at Sophia and the Parika Agro-Packaging Facility. NGMC also operates the Guyana Shop that purchases locally made, value-added, appropriately packaged products and sells them in this shop, promoting and raising the awareness of the population. These products are also promoted overseas at various fairs and special events.
DESCRIPTION OF SUBSECTOR SUPPLY CHAIN WITH GENDER DISAGGREGATED DATA

While gender disaggregated data on the mango supply chain was not available for this study, there are general country data that can guide the thought process.

The main areas of population concentration in Guyana have not changed over the decades, although some of the sparsely populated regions have begun to show increased numbers. Region 5 (Figure 1), where the villages are located that make up the Region 5 FSC contained 7 percent of the population according to the 2002 population census. Further, Region 6 had 17 percent of the population and Region 3, where the East Bank Essequibo FSC is located, had approximately 14 percent of the population.

The four main hinterland Regions (1, 7, 8 and 9), though covering nearly three-quarters of the total land area, are sparsely populated and contain less than 10 percent of the population1. Further to the above, the Guyana 2002 population census notes that the percentage of gender distribution of the population by regions is similar to the national. With the exception of Region 4, the proportion of males is higher than for females in 2002 census. The largest gender differentials – where men outnumber women, are seen in Regions 8, 1, 7 and 9 in rank order.

It should be noted that the Guyana 2002 population census observed that the high proportion of women, in what would be called non-economic activity (unpaid), is generally misleading as many women who report being engaged in ‘home duties’ are usually involved in some small activity, e.g. making sugar-cakes, mitai, etc. or tend a garden to supplement family income or have a small income of their own. Moreover, some other non-economic activities performed by women such as cooking or caring for the family are usually chores that are normally paid for where women work and should be valued as a contribution to the household budget.

For the most part, non-traditional agricultural produce has a rather traditional marketing chain of farmer to wholesaler (intermediaries or exporters) to retailer to consumer. These are the four main actors involved in the value chain. Often one person or one family plays several roles and it may not be clear who is doing what. Figure 2 shows the wholesaler (intermediaries) may supply the local retailer, supermarket, exporter or consumer directly. There is no specialized wholesale market even though wholesaling activity is very common at several key trading or marketing points throughout the country. At the same time intermediaries buying directly from the farmgate is common in most regions. In addition, Regions 2, 3 and 4 farmers in particular have greater options for directly selling to retailers, supermarkets, exporters and processors.

IDENTIFICATION OF ONGOING WORK

Ongoing studies of mango are being undertaken at the University of the West Indies, Saint Augustine Campus in Trinidad and Tobago at several levels involving production and postproduction activities. Dr L. Robert-Nkrumah in the Department of Food Production is investigating preharvest factors such as cultivar selection, propagation

methods, fertilizer regimes and water relations on growth and development. Also her studies involve the effects of growth regulators on flowering and fruiting of selected cultivars.

Dr A. Khan is investigating techniques to control fruit fly and seed weevil infestations. Post-harvest studies on mangoes are being done by Dr L. Wickham and Dr M. Moham-
med. These include effect of temperature time studies on ripe fresh-cut mango slices under refrigerated and non-refrigerated conditions. Post-harvest studies are also being done on various hot water treatments to extend the shelf-life of mango cultivars.

Physiological manifestations of chilling injury are being investigated on cv. Long, Starch and Julie. Physico-chemical quality attributes of modified atmosphere packaging of cv. Julie is being undertaken by undergraduate students. At the The Ministry of Food Production Land and Marine Affairs (MFPLMA), in Trinidad and Tobago Mr A. Juman is screening several mango cultivars for development of value-added products. Dr M. Mohammed has submitted a book chapter relating to post-harvest logistics management of mango.

DESCRIPTION OF THE MARKETING SYSTEMS
In Guyana there is a strong year-round demand for ripe mangoes – primarily the Buxton Spice variety. However, there is limited seasonal supply that impacts on quantity supplied and prices. Mangoes are mostly purchased directly by consumers from municipal markets and roadside vendors. Apart from Buxton Spice, other varieties include Julie, Long and Turpentine mango also referred to as Belly Full. Long mango is mostly used green to make achar, the main value-added mango product in Guyana.

Mangoes are still largely grown traditionally as scattered trees and, as a result, the crop has not yet evolved as an orchard crop in Guyana, where it is largely grown under a no-input, low cost (almost no-cost), low technology system. The main costs are in fact for harvesting.

Other observations of the mango supply chain in Guyana were as follows:
- There was no organized marketing of mangoes. There were however some medium-scale buyers of green mangoes for achar production.
- The collection or distribution system is in the hands of intermediaries and there is no true storage other than, on average, a one-day hold over by intermediaries of mangoes bought from farmers.
- Farmers were mostly unorganized when it came to marketing. They were engaged in, individual production, made individual sales to intermediaries and therefore had no group bargaining power. Individual sales of green mangoes were to medium sized processors or to smaller achar makers (cottage industry type) who sometimes bought green mangoes directly from intermediaries (wholesalers).
- Farm to market packaging continues to improve – a shift away from sharp-edged baskets was observed as producers use more plastic tubs or buckets and intermediaries place these on multi-shelved pickups or trucks. On-farm packaging was still very traditional – baskets, buckets, bags and open tractor drawn trailer or boat.
Chapter 4
Study findings

SECONDARY DATA AND KEY-INFORMANT (EXPERT) INTERVIEWS

Literature review
Mango is considered as one of the most farmed tropical fruits in the world, accounting for approximately 50 percent of total fruit production (Jedele et al., 2003). According to the FAO (2010), the main mango producers worldwide in 2008 included India (13 649 400 tonnes), followed by China (3 976 716 tonnes), Thailand (2 374 165 tonnes), Indonesia (2 013 123 tonnes) and Mexico (1 855 359 tonnes). Mango production is concentrated in developing or emerging countries.

In developed countries such as the United States, mango production remains marginal (less than 3 000 tonnes were produced in 1999). The top five mango importers worldwide in 2007 were the United States (295 321 tonnes), The Netherlands (111 830 tonnes), United Kingdom (57 381 tonnes), United Arab Emirates (47 038 tonnes) and Germany (46 762 tonnes).

The top mango exporters were India (240 858 tonnes), Mexico (236 004 tonnes), Brazil (116 271 tonnes) and Peru with 82 512 tonnes (FAO, 2010). Mexico is considered the principal mango supplier to the United States while Brazil and African countries supply Europe (Jedele et al., 2003). The demand for mango is growing in both developed and developing countries, leading to increased mango production and heavier competition among mango exporting countries (Jedele et al., 2003). The United States per capita mango availability (proxy for mango consumption) sharply increased from 0.17 kg in 1988 to 0.93 kg in 2003 (USDA-ERS, 2010). This consumption growth has been guided by factors such as year-round fruit availability and lower prices (Evans, 2008).

The total volume of fresh imported mango in the United States varies throughout the year, with noticeably low supply levels that match with medium to high prices as shown in the period from September and December 2010. The period from April to June has the highest supply volumes and lowest prices compared to other seasons in the year. Exporters have identified the September–December window as an opportunity to obtain higher prices by increasing exported volumes to the United States during this season.

The increasing volumes of mangoes in international trade have shifted the mode of transport from primary air freight to marine containers. This has only been possible because of the strict attention to fruit maturity and temperature control (Yahia, 2011).

Data review
Table 4.1 shows the volume of mangoes that were produced in Guyana between 2007 and 2012. Production decreased from about 4 200 tonnes in 2007 to 1 500 tonnes n 2012.

Data on area of mangoes planted and the volume of processed mango products (such as achar and jam) are not available. These are all outputs of small, primarily home-based cottage industries that fall outside the normal monitoring system.

The authors are not aware that there is any gender disaggregated data related to the mango value chain, however, it is common knowledge

<table>
<thead>
<tr>
<th>Year</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume of mango (Tonnes)</td>
<td>4,253</td>
<td>3,609</td>
<td>1,225</td>
<td>2,524</td>
<td>1,604</td>
<td>1,499</td>
</tr>
</tbody>
</table>

Source: New Guyana Marketing Corporation
that mangoes are harvested primarily from scattered trees in the backdam (deep in the countryside). In Guyana, harvesting and transportation of mangoes (by tractors, boats, pickups or animal drawn carts) from the backdam to the homestead are challenging tasks, particularly during periods of rainfall as the roads to many of the mango growing areas are inadequate. These are primarily male-dominated activities. Both men and women farmers are involved in direct wholesaling and retailing; and this is the same for wholesaling and retailing by intermediaries. Retailing at the various municipal and other markets is almost exclusively a female activity.

Table 4.2 shows the volume and value of mangoes exported from Guyana during the 2008–2012 period. Export volume exceeded the 300 tonne mark during the 2008–2010 period but decreased to 170 and 182 tonnes respectively in 2011 and 2012. NGMC data also shows that relatively small quantities of achar were exported during the 2008–2012 period. The only exception was in 2011 when 21 tonnes valued at USD 102 000 were exported.

With respect to prices, the markets to observe are the Bourda and Stabroek municipal market wholesale and retail prices; as most produce entering Georgetown, traditionally goes through Bourda and Stabroek. Regions 4 and 5 are considered to be the main suppliers of mangoes into Georgetown.

Table 4.3 shows that during the 2007–2012 period that Bourda market wholesale prices were at least 16 percent higher than Stabroek market wholesale prices. While there are no recent studies on volumes and price movements of produce traded at these or other municipal markets, it is generally accepted that most fresh produce traded in Guyana pass through these two markets daily. Observations at these markets suggest that men and women are engaged in wholesaling but women are mostly involved in retailing.

Table 4.4 shows that during the same 2007–2012 period average annual retail prices for mangoes were always higher at Bourda than at Stabroek. The percentage ranged between 14 percent in 2010 and 36 percent in 2011.

**Principle mango supply chains**

Mango production is widespread and three main supply chains were identified: West Coast Berbice area, Region 5; Upper and Mid East Coast Demerara area (Mahaica, Clonbrook, Ann’s Grove, Victoria), Region 4 and various locations within
Regions 2 and 3 (Figure 2). The supply chains spread across Regions 2, 3, 4 and 5 where mostly mature mangoes, referred to as ‘full ripe’, ‘fresh picked’ or ‘turning’ mangoes are traded, with the main market being Georgetown and the environs. From Georgetown, produce is distributed to other areas in need.

Table 4.5 provides details on the supply chain in the West Coast Berbice area, Region 5. Mangoes are used mostly as firm, ripe mangoes; a smaller quantity is used at the green stage to make achar, to be sold as fresh sliced green mango or, in at least one case, frozen slices for export. The general view is that a very high percentage of mangoes in each crop are not used. Much remains under the trees because of low prices, high transportation costs and inadequate access to markets from points of production.

Selection of food supply chains

Table 4.5 shows that in Guyana, the West Coast Berbice, Region 5 is an important mango supply chain. Region 5 is a main producing area that supplies Georgetown and the environs. In terms of economic importance, mango production is considered to be economically important in the West Coast Berbice area, as opposed to the Upper/Mid East Coast Demerara area where producers have fewer alternative ways of earning an income than those in areas where rice and cattle are produced. Mango production in the West Coast Berbice area contributes to employment-generation as well as to poverty reduction; but is rated low in terms of contribution to food security because people living in this area have several other choices for earning an income. Mango and mango achar exports from Guyana in 2008 contributed USD 500 000 to foreign exchange generation, but fell to USD 318 000 in 2012. The data is not disaggregated by region so it is estimated that the West Coast Berbice area was responsible for 50 percent of the export volume, which is equivalent to USD 159 000.

HISTORY OF GOVERNMENT AND PRIVATE SECTOR INVOLVEMENT IN THE SUBSECTOR

Agriculture employs about 33 percent of the population in Guyana and generates approximately 25 percent of GDP. In addition, almost 50 percent of Guyana’s export earnings come from agriculture. Agriculture is the pivotal sector for ensuring food and nutritional security, sustainable development and for income-generation. Sugarcane and rice are the pillars of Guyana’s agriculture industry. Together, they are referred to as the traditional agricultural sector and coupled with the non-traditional agricultural sector; they are the main sectors for employment opportunities for most of the rural and urban population.

The Guyana economy is still heavily dependent on the primary agricultural sector; support for the sector is a testimony to the importance placed by the Government of Guyana (GOG) on this sector. The domestic economy continues to expand at approximately 4 percent per year, with a resultant increase in disposable income that will positively affect the demand for all agricultural products. However, from its inception, the agricultural sector has recognized diversity and crop improvement as the nucleus of its sustainability. Traditionally rice literally connotes food. It is both the material and psychological basis of food security and along with sugar has consistently been the highest earning agricultural export.

In an effort to meet the challenges of competition, to exploit niche opportunities and to decrease dependency on single commodities, the Government’s attempts to promote and improve non-traditional agricultural enterprises are commendable. The non-traditional crop sector comprises about 70 economically important food plant species. With the assistance of various donor agencies, the Government has, over several decades, implemented several projects for the benefit of farmers of non-traditional crops inclusive of
<table>
<thead>
<tr>
<th>Stage in food supply chain</th>
<th>Location</th>
<th>Months of the year</th>
<th>No. of actors</th>
<th>Products</th>
<th>Volume (tonne)</th>
<th>Facilities/Equipment</th>
<th>Duration/Distance</th>
<th>Inputs and services</th>
<th>Cost of production GYD</th>
<th>Value of products GYD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary production</td>
<td>West Coast Berbice</td>
<td>December – February; June-August</td>
<td>100 Mangoes</td>
<td>60 Tractors and ploughs for land preparation; cutlass, forks, shovels</td>
<td>6 months</td>
<td>Minimal inputs – maintenance of old trees</td>
<td>100 000/ha</td>
<td>930 000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Harvest</td>
<td>West Coast Berbice</td>
<td>December – February; June-August</td>
<td>100 Mangoes</td>
<td>6 Harvested by hand and by shaking: placed mostly in bags or buckets or directly into trays of animal drawn carts or trays of tractor-drawn trailer; crates rarely used from farm to homestead or to market</td>
<td>6 months</td>
<td>Labour to harvest, and load up as required</td>
<td>200 000/ha</td>
<td>100/kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-harvest handling</td>
<td>From farm (West Coast Berbice) to wholesale market / retail market;</td>
<td>December – February; June-August</td>
<td>100 Mangoes</td>
<td>48 Bags, buckets, tubs</td>
<td>104 km from farm to homestead to Georgetown markets; about 3 hours (in some cases mangoes are harvested the day before market day)</td>
<td>Labour – washing, sorting, grading, packaging</td>
<td>250 000/tonne</td>
<td>150/kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other post-harvest handling</td>
<td>From farm (West Coast Berbice) to processor / exporter</td>
<td>December – February; June-August</td>
<td>100 Mangoes</td>
<td>48 Crates (processor or exporter uses only crates that he provides)</td>
<td>6 months/104 km from farm to Georgetown; about 3 hrs</td>
<td>Labour for washing, cutting, bagging</td>
<td>33 000/tonne</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transportation</td>
<td>Several municipal markets including; retailing at roadside markets as well.</td>
<td>December – February; June-August</td>
<td>20</td>
<td>45 Pickups, vans, trucks, etc.</td>
<td>104 km from farm to Georgetown markets; about 3 hrs</td>
<td>Driver, labour to load and unload</td>
<td>35 000/tonne</td>
<td>wholesale – 300/kg retail – 500/kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wholesale/ Retail market sales</td>
<td>Timhehri Int. Airport – Soesdyke, EBD</td>
<td>December – February; June-August</td>
<td>5</td>
<td>Fresh ripe and fresh cut frozen</td>
<td>6 months/42 km from packinghouse to airport; 1 hour</td>
<td>Labour to clean, chop, pack, label, load, unload boxes; brokerage services</td>
<td>150 000/tonne</td>
<td>800/kg</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

USD 1.00 ≈ GYD 200.00 approximately
the three commodities of focus for this analysis: cassava, tomatoes and mangoes.

These projects have included the International Development Bank-funded Agricultural Export Diversification Project (ADP), the IFAD-funded Poor Rural Communities Support Services Project (PRCSSP) and the Rural Enterprises and Agricultural Development Project (READ); the European Union-funded Guyana Micro-Projects Programme (GMPP); and the USAID-funded Guyana Trade and Investment Support Project (GTIS).

As it relates to value-addition and processing, a 2003 IICA/CIDA/CPEC study on marketing organic produce from Guyana observed that, “Inadequate power and potable water supplies are major constraints to the development of more appropriate processing, handling and storage facilities for the domestic market. They are obviously at the same time major limitations to accessing the export market. In addition, Guyana has a shortage of trained post-harvest technology technicians.”

Further, a paper commissioned by the International Labour Organization (ILO) (2005) observed the constraints to agroprocessing as: infrastructural deficiencies, including expensive and unreliable electricity; sporadic supply of low quality water; lack of access to affordable financing; high shipping costs; deficient market information; inappropriate technologies; inadequately prepared human resources; and high shipping costs/inadequacy of port facilities.

In a 2007, study implemented by CHF-Partners in Rural Development and funded by the International Development Bank, nineteen agroprocessors and cottage industry processors from the six coastal regions of Guyana volunteered information on their relationships with farmers. They identified the areas of need as being financing; technical help – factory design, process flow; equipment; help to find new customers or support for exhibitions, study tours, etc.; links to potential importers; negotiation skills; website development; good agricultural practices (GAP) and Hazard-Analysis and Control of Critical Points (HACCP) standards; links to investors; product development to meet markets; sourcing packaging materials (bottles, caps, etc.) at cheaper prices; and applied research at the field level. Many of these issues are currently being addressed through projects such as the READ, GEF Small Grants Programme and the Credit Guarantee Facility of the Small Business Bureau.

**INVENTORY OF ACTIVITIES AND LESSONS LEARNED FROM PAST AND ONGOING INTERVENTIONS**

The Guyana Trade and Investment Support (GTIS) Project, was a joint project of the Government of Guyana and the Government of the United States, that was geared to provide support to enterprises, private sector organizations, and government institutions to identify new markets for Guyanese products and increase exports to regional and international markets. The project, which was funded by the United States Agency for International Development (USAID), followed a market-led strategy, identifying global demands and then seeking to fulfil them according to the resources available in Guyana.

The project emphasized support for private sector driven initiatives and activities, based on the premise that ultimately it is private enterprise that will provide the impetus required to achieve sustainable export expansion, employment, income-generation and economic growth in Guyana. There were two phases of the project between 2004 and 2012.

During the life of the project, GTIS conducted several workshops on the techniques of pre and post-harvest handling for non-traditional agricultural products. These workshops further emphasized the need, and provided recommendations, for addressing cold storage and packaging issues. As an example, collaboration between the New Guyana Marketing Corporation (NGMC), National Agricultural Research Institute (NARI), Laparkan and Guyana Agribusiness Association led to a pilot project to produce and market a special ‘bull nose’ hot pepper for an identified export market in the United States.

GTIS ran a series of trials to test the entire value chain, having the hot pepper and butter-nut squash grown and exported to prospective buyers. In addition, several containers of mixed produce were exported. These pilot tests highlighted the need for improvements in cultivation.
techniques, packing facilities, cold storage, post-harvest handling, packaging and transport and logistics and it became clear that Guyana needed not only buyers for its produce, but needed to address several gaps, one of which was the issue of post-harvest losses.

One of the lessons learned during the GTIS Phase 1 project in the area of post-harvest handling was, “Improved post-harvest handling throughout the supply chain is critical to achieving export quality standards. This process should begin in the field, where farmers should use the necessary equipment to protect harvested produce during transport, such as plastic crates and packing material, along with training in their proper application. Sector stakeholders should also expand the cold chain by including cold storage facilities at pack houses, an important factor in reducing spoilage in the hot climate of Guyana”.5

CURRENT POLICY FRAMEWORK ON SUBSECTOR FOOD LOSSES
The Guyana Vision for Agriculture 2020, entitled, *Agriculture as our vehicle for sustained economic and social prosperity* is perhaps the most recent (2012) MOA policy document, which lists the opportunities, challenges and the strategic thrust for the sector to 2020. It identifies 20 priorities that are obviously interrelated but priorities 7 and 8 are speak most directly to post-harvest losses. For the ease of reference these are reproduced below.

The Jagdeo initiative, which provides the

---

Priority 7 recognizes the importance of Transportation, Packaging, Storage and Cargo Space Facilities as crucial elements to support a modern and more effective agricultural sector.

This important priority was identified in the Jagdeo Initiative as a Key Binding Constraint for the development of agriculture in CARICOM. In Guyana, we will more comprehensively address the issue of transportation, packaging and storage facilities, including refrigerated storage facilities and refrigerated trucks, port cargo spaces and improved river and sea transportation. Food production includes the production of some seasonal products, but consumption is usually continuous. Food security (priority #11), therefore, depends upon robust systems of packaging and storage, including frozen, chilled and dry. Insufficient cargo space and irregular shipping schedules are major impediments and these must be addressed. As we extend agriculture and move beyond the present cultivated land, and expand export capacity, this priority will become a critical factor. 

Priority 8 identifies Marketing as an important area for realizing the vision of an agricultural sector being the vehicle for economic and social prosperity in Guyana.

Without marketing we will not be able to make agriculture profitable. Particular focus of our agriculture enterprise has to be on linking farmers, especially small-scale farmers, with markets. Successfully facilitating and supporting efforts to link small farmers to dynamic markets have become important issues on the agricultural and rural development agendas. The Jagdeo Initiative for the development of agriculture in CARICOM recognized the need for effective marketing as a Key Binding Constraint. We must have a robust export-marketing programme. In this regards, development of a Market Information System is critical. We will work with our partners to complete and operationalize a Market and Data Information System as soon as possible. Guyana must pursue production geared towards establishing a Brand Guyana and develop Brand Guyana as a reliable high quality product. Guyana’s Demerara Gold Sugar, Eldorado Rum etc. are examples of Brand Guyana. We must ensure similar success stories for other agricultural products out of Guyana. We will work with our farmers to guide production to satisfy changing consumer preferences, establish grades and standards, manage risks (farmers and exporters) and ensure greater fidelity of contracts. We will work with stakeholders, other than farmers and exporters, to create a more export-friendly environment. In particular, we will promote better understanding and greater cooperation of stakeholders such as shippers and the Custom and Excise Department. We will be proactive in removing hiccups such as the two weeks time period for processing custom documents and the regular unavailability of Custom Officers to process and approve shipment at Ports of Exit.

---

framework and strategy for regional agricultural development (CARICOM, 2011) and was spearheaded by President Bharrat Jagdeo of Guyana, encompasses the entire CARICOM agrifood/product system and aims for “the creation of an enabling economic and business environment for competitive and sustainable agricultural and rural development”.

Key critical constraints affecting agriculture in the region were identified and strategies developed to overcome these constraints within the context of improved international competitiveness. The strategies identified: creating an enabling environment for business and private sector enterprise, including farmers; improving supply capacity and competitiveness; establishing and strengthening of private sector organizations; and refining the resource management capabilities for business and trade efficiency.

PRELIMINARY ANALYSIS OF POST-HARVEST LOSSES (SCREENING)

General view of the priority subsectors

Based on the information gleaned from previous studies and from visits to mango producers, retailers, wholesaler, processors and exporters, the value chain was determined as shown in Figure 1. In Guyana the main cultivar is cv. Buxton Spice, which is used both as a fresh fruit and as processed frozen slices. Both fresh ripe fruit and frozen slices are sold locally and also exported from Guyana to ethnic markets in Canada.

Mangoes are harvested at the mature-green stage of maturity (for processing into kuchelar as selected value-added products) and at the turning stage of maturity when it is harvested for the fresh fruit market (fresh-cut slices sold fresh or as frozen slices or for subsequent ripening as fresh ripe table fruit) and hereby designated as CPL#1. Mangoes are normally borne in clusters and are handpicked directly from the lower branches, a harvesting rod is used for the higher branches. In the latter case the fruit is collected into the pouch attached to a harvesting rod. Alternatively the mangoes are harvested by handpicking and the use of a bag to collect, or by shaking branches with fruit clusters.

Mature green and turning fruit is peeled, the flesh is sliced from the seed containing the endosperm and the flesh shredded, squeezed to remove some of the juice, mixed with salt and spices, made into kuchelar, and then bottled. The steps involved in making this value-added product is seen as CPL#2. On a point of distinction, there is a difference between fresh-cut and fresh-cut frozen slices. Fresh-cut slices are the mature-green to turning mangoes that are sliced at the point of sale in public markets in 0.9 kg and 1.8 kg (2 lbs and 4 lbs) packages and used within a day at the household level for cooking into curry mango. However the frozen slices are mainly sold at supermarkets and later thawed and cooked into a curry mango and this represents CPL#3. For the table ripe fruit, a series of post-harvest packinghouse operations followed by retail marketing are conducted as shown in Figure 4 and designated as CPL#4.

Identifying the stages of the supply chain where the losses are higher

The CLPs identified were harvesting CLP#1, processing into value-added products such as kuchelar and or chutney is CLP#2, processing into fresh-cut slices or frozen fresh-cut slices is CLP#3 and retail marketing for the fresh fruit is CLP#4 (Figure 4).

Field data were collected by conducting a survey of selected producers, wholesalers, household processors through a structured questionnaire according to the methodology described earlier. Data were taken from purchasing samples of fruits at the 4 CLPs and taking qualitative data: fresh weight (digital scale), firmness (Warner penetrometer), colour (USDA colour chart), pericarp thickness (Vernier caliper), total soluble solids (Stanley refractometer). These measurements were taken on fruit at the various CLPs identified above.
**FIGURE 4**
Mango value chain showing the critical loss points (CLPs)

**Farmer/Producer**
- Harvest mango
- Mature green
- Mature turning
- Latex removal
- Field containers
- Load into vehicles

**Mature green**
- Wash
- Peel
- De-stone
- Grade
- Dry
- Kuchelar, Chutney

**Mature (Turning)**
- Wash
- Hot water treatment
- Condition for 24 hrs at 25-30 °C
- Storage ripening 18-20 °C / 90-95%RH
- Fresh fruit market
- Processor (Juice, jam, jellies, baked products)

**PROCESSOR**
- Freeze slices
- Red mango
- Amchar, Pickles
- Wholesale
- Retail
- Export
- Supermarket

**CONSUMERS**

**TRANSPORT**
Chapter 5

Food losses

CRITICAL LOSS POINTS: TYPE AND LEVEL OF FOOD LOSSES

The types of losses associated with mango were both quantitative and qualitative. The critical loss points were based on whether mangoes were marketed as table ripe or as value-added products. The critical loss points for ripe fruit occurred at field harvest (CLP#1) and at the packinghouse where the mangoes were sorted, graded and ripened for the retail market (CLP#4). Mangoes were harvested at the mature green to turning stages of maturity to be processed into value-added products and grated to make kuchelar (CLP#2) (Figure 5).

Mature green, as well as fruit at the turning stages of maturity were sliced sometimes at the retail market or at small-scale processing facilities to produce fresh-cut slices that were eventually frozen at the household level or wholesaled by the processor to supermarkets to be sold as frozen mango slices (Figure 6). The frozen mango slices were designated as CLP#3. In Guyana cv. Buxton Spice is used for table ripe fruit, frozen slices and kuchelar production. However smaller quantities of cv. Long are processed into pickled products. The losses are shown in Table 5.1.

SAMPLE ANALYSIS

The average of three replicates, with each replicate consisting of ten mangoes were analysed for stage of maturity, fresh weight, length, width, firmness and total soluble solids as shown in Table 5.2. Data taken on prevailing environmental conditions in Guyana and Trinidad and Tobago averaged 30–32 °C and 50–60 percent relative humidity. Guyana growers and processors have secured export markets in Canada.

CAUSES OF LOSSES

Quality losses – The stage of fruit maturity at harvest depends on how the fruit is to be used. In

<table>
<thead>
<tr>
<th>Stage in food supply chain</th>
<th>Quality reduction (%)</th>
<th>Quantitative losses (%) of weighed losses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Handled</td>
</tr>
<tr>
<td>Maturity variation</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Packaging</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Transportation and unloading</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Ripening and storage</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Retailing</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Critical Loss Points (CLP)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Harvesting CLP#1</td>
<td>30</td>
<td>100</td>
</tr>
<tr>
<td>Making kuchelar CLP#2</td>
<td>15</td>
<td>19.5</td>
</tr>
<tr>
<td>Making frozen slices CLP#3</td>
<td>15</td>
<td>21.0</td>
</tr>
<tr>
<td>Retail Market CLP#4</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Guyana mango producers and marketers focuss on cv. Buxton Spice for use both ripe and for processing. Accordingly, mangoes were harvested at several maturity stages from immature green to mature green, turning as well as when ripe. Fruit sorted in the field at each harvest is divided into processing and table ripe with the former comprising immature green and mature green fruit and the latter turning fruit for ripe fruit.

Quality attributes for cv. Buxton Spice are presented in Table 5.2. In Guyana, although cv. Long trees are not very tall farmers used a combination of ladders, harvesting rods equipped with hooks and pouches (Figure 7), physical damage still accounted for reductions in fruit quality ranging from 15 percent to 25 percent (Table 5.1). Variations in fruit maturity at harvest resulted in a lack of uniform ripening and this was often reflected in poor skin and flesh colour as well as inferior taste and flavour.

Physical injuries incurred during transportation from the field to the packinghouse and rough loading and unloading led to skin abrasions and compression, which impacted negatively on cosmetic quality and appearance at wholesale and retail markets (Figure 8). Mango is a climacteric fruit and capable of autocatalytic production of ethylene to enable the ripening process and eventual senescence. As such physical injuries accelerated quality losses during retailing and wholesaling operations. Further decline in fruit quality attributes were associated with prevailing high temperatures and low relative humidity at retail and wholesale markets thereby stimulating respiration and ethylene biosynthesis.

In Guyana mango producers and marketers encounter higher quality losses than their Trinidad and Tobago counterparts. More fruit is harvested and as there was a wide variation in fruit maturity there was more latex stain damage (Figure 9) from

| TABLE 5.2 | Quality attributes of mango in Guyana |
| Parameters | Harvesting | Processor kuchelar | Frozen slices | Retail market |
| Maturity @ harvest | Turning | Mature green | Mature green | Ripe |
| Fresh weight (g) | 798 | 779 | 790 | 766 |
| Length (cm) | 8.8 | 8.5 | 8.9 | 8.1 |
| Width (cm) | 7.6 | 7.4 | 7.8 | 7.7 |
| Firmness (g/force) | 27 | 25 | 22 | 19.5 |
| Total soluble solids (%) | 7.7 | 7.7 | 7.8 | 9.9 |
immature fruit coming into direct contact with more mature fruit. A significant quality problem was observed when the fruit was packed into large polypropylene bags which, when filled, weighed as much as 65 to 70 kg.

Transportation from the field to packinghouses was often by boats and the nature of the inner curvature of these vessels and high stacking of bagged fruit accounted for quality reductions of 20 to 30 percent (Table 5.1). Harvesting of fruit was often accomplished by shaking branches and beating fruit clusters with rods that were not equipped with pouches. Even where infield transportation methods were used, such as pick-ups, tractor trailers and trucks, this was over long distances and slippery terrain. Harvested mangoes were not protected from the sun, which promoted quality losses because of the high respiration, which became more challenging as bags were poorly ventilated.

Quantitative losses – Post-harvest losses of mangoes were 28 percent in Guyana (Table 5.3). Losses at harvest based on poor harvesting methods, unavailability of harvesting aids, inappropriate harvesting containers and prolonged duration of harvested fruits exposed to high temperatures infield prior to loading and transportation accounted for losses at CLP#1 for mango producers and marketers were 17.5 percent (Table 5.1). Physical damage included bruises, cuts, cracks, bird damage, abrasions, stem end incisions, compression and punctures and these were generally higher for cv. Buxton Spice.

It was observed that there were significant differences in physical damage between cultivars harvested in Trinidad and Tobago and Guyana, because mangoes in Guyana are subjected to a higher degree of rough handling at harvest. This is because Guyana growers harvest all fruit within a cluster because the mangoes can be used for both processing and non-processing purposes. On the other hand in Trinidad and Tobago harvesters select fruit within clusters that are only physiologically mature and, in some cases, partially ripe. Normally these mangoes are within easy reach, ladders are used and picking rods with an attached pouch for fruit that is located on higher branches.

In Guyana, in several mango fields immature fruit showed evidence of internal fractures when allowed to fall onto the hard soil surface. This was frequently observed where harvesting rods without a pouch attachment were used. Because fruit is overpacked in polypropylene bags, physical damage caused by scuffing occurred as the surfaces were abraded by the stems of other fruit.
and the sides of the rough bags. The dominance of scuffing in mangoes harvested from fields in Guyana compared to Trinidad and Tobago was related to vibration when individual mangoes rub against each others.

Frequent loading and unloading, compression of fruit at the bottom of unpadded containers and vibration caused bruising of the fruit flesh, which showed up internally as discoloured, water-soaked areas. Note, ripe mangoes are more susceptible to bruising. The physical injuries sustained during harvesting created other problems, including increased respiration and ethylene production, increasing water loss and also facilitated the attack and penetration of disease causing agents.

Physiological disorders included premature ripening, internal breakdown (Figure 10) and lenticel spotting and this occurrence was high at CLP#4 than CLP#1. Symptoms of water stress were observed, which results in shrivelling, more so at CLP#4 than at CLP#1. Improper temperature and relative humidity management were directly responsible for water stress. The cultivar Buxton Spice appeared to have a thinner skin with less cuticular wax than cv. Julie and accounted for more water loss through stomata and lenticel openings thereby resulting in greater reduction of fruit weight, shrivelling and uneven ripening at CLP#4. However in both cultivars the area near the stem scar was more susceptible to water stress than the rest of the fruit and was usually the first to show shrivelling. Scuffed areas on the surface of the fruit also collapsed and shrivelled from water loss.

Pathological and entomological damage was recorded as 7 percent of the mangoes at CLP#1 cv. Buxton Spice, which increased to 9 percent at CLP#4 (Table 5.1). The main post-harvest diseases are associated with fungal infections from anthracnose (Figure 11), secondary infection from scars caused by latex stains and stem end rot resulted from infections that occur on trees or during harvest. These latent infections were less visible at CLP#1 than at CLP#4. Anthracnose developed from quiescent lesions on the peel while stem end rot was associated with poor harvesting techniques and from fruit coming into contact with the soil during harvest.

High levels of entomological losses were attributed to insect pests such as scale insects (Figure 12) and fruit fly infestations (Figure 13). Both pests prevented mangoes from being exported from Trinidad and Tobago. Poor orchard sanitation management whereby dropped fruit was allowed to remain on the ground caused the larvae of fruit flies to emerge from infected fruit and pupate in the soil. The weevil is primarily a pest of the mango seed (Figure 14), with one seed sometimes supporting up to five larvae. Premature fruit drop were observed in several mango fields in Trinidad and Tobago and could be related to severe weevil infestation. Damage caused by birds was observed in both Guyana and Trinidad and Tobago.

TABLE 5.3
Nature and types of post-harvest losses of fresh table ripe mango in Guyana

<table>
<thead>
<tr>
<th>Types of post-harvest loss</th>
<th>CLP#1 Percentage</th>
<th>CLP#4 Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical damage</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Physiological disorders</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Pathological and entomological</td>
<td>7</td>
<td>9</td>
</tr>
</tbody>
</table>

FIGURE 10
Physiological disorder, internal breakdown

©MOHAMMED AND CRAIG
Chapter 5 – Food losses

TRACING OF VALUE ADDED PRODUCTS – KUCHELAR AND FROZEN SLICES

Post-harvest losses of kuchelar and frozen slices were measured at CLP#2 and CLP#3 as shown in Table 5.4. The post-harvest losses related to the value-added products kuchelar and frozen slices were determined by tracing and tracking the various processing steps as seen in Figure 1, which were conducted by processors who sell to supermarkets. Total losses for kuchelar were 19.5 percent for cv. Buxton Xpice (Table 5.4). Physical damage to fruit prior to processing into kuchelar were 10.5 percent, while pathological and entomological damage in the case of frozen mango slices post-harvest losses were 21 percent (Table 5.4).

Physiological disorders did not exceed 3 percent when fruits were sorted prior to processing. Although mango is considered to be fairly tolerant to heat injury, exposure of mangoes at temperatures above 32 °C for extended periods in the field, during transit, at retail and wholesale display, pulp temperatures accelerated to 36 to 38 °C. In this investigation mangoes examined showed external symptoms of heat injury such as lenticel spotting and skin browning or scalding with definite evidence of secondary disease development. Internal symptoms of heat injury included mesocarp browning and tissue cavitations.

FIGURE 11
Anthracnose infections on cv. Julie

FIGURE 12
Scale insect damage cv. Long

FIGURE 13
Fruit fly infestation cv. Julie

FIGURE 14
Mango seed weevil cv. Long
FOOD LOSS REDUCTION STRATEGIES

The following recommendations are applicable to countries including Guyana where mango production and marketing exist.

Field harvest CLP#1

- Mangoes must be harvested at the appropriate stage of maturity to attain the best eating quality and attractive internal quality (Figure 15 and Figure 16). Harvesters should be trained at workshops as well as during field demonstrations on how to distinguish immature from mature fruit. While immature mangoes have a flat shape in profile, with shoulders that slope down below the pedicel insertion, mature fruit have full cheeks and raised shoulders at the stem end. Harvesters must handle fruit with care in order to minimize fruit damage and use harvesting aids such as ladders, clippers, harvest baskets, and harvesting rods with netted pouches.

- Harvested mangoes must be protected from exposure to direct sunlight while awaiting transport to the packinghouse. Protect harvested fruit by placing under shade trees, cover with a light colored cloth or broad leaf or schedule harvesting for the cooler parts of the day such as very early morning or late afternoons.

- Prevention of latex damage and stains on harvested fruits should be implemented by harvesting mangoes with a long stem 5 cm or longer since latex does not drip from fruit with a long stem. Alternatively stems should be trimmed to the abscission zone and immediately placed with the stem end down to allow the latex to drip without touching the fruit peel. A flat, plastic rack is recommended to hold the mangoes while the latex drips out. The duration of latex removal varies from 20 minutes to up to 4 hours. About 24 hours after harvest latex will no longer drip.
from the mango even if the stem is clipped shorter. Other methods include desapping in a 1 percent solution of calcium hydroxide or washing the fruit in 1 percent aluminium potassium sulphate.

- Shallow, light coloured plastic crates (Figure 17) should be selected instead of polystyrene bags. These crates are washable, stackable, ventilated and durable.
- Select a transport method that allows for ventilation during transit from field to packinghouse.
- Provide frequent training to harvesters to include harvest maturity indicators, latex removal procedures, good sanitation practices, appropriate pre-cooling methods and worker safety.

**Value-added mango products at CLP#2 (kuchelar) and CLP#3 (frozen mango slices)**

- Processors must stipulate that suppliers must deliver mangoes sorted according to cultivar, size, skin and flesh colour and shape and establish minimum standards for physical damage. Fruit with fruit fly, bird damage (Figure 18) and seed weevil should not be accepted.
- All cutting tools and utensils should be sanitized, made of stainless steel with sharp cutting edges. The use of very sharp tools to slice mangoes (Figure 19) would reduce cellular damage and leakage of cellular contents and enzymatic browning. Trimming flesh near the stem is also necessary to minimize browning.
• Cut frozen slices must be washed, rinsed and pre-packaged immediately after cutting to minimize enzymatic browning. Other recommended post-harvest treatments to limit softening and browning include dipping in 5 percent calcium chloride solution prior to freezing.

• Sanitation of the whole fruit and the processing facility and maintaining a low temperature environment during all fresh-cut processes is recommended in order to reduce potential microbial problems. A chlorine solution of 200 ppm that is between 25 to 43 °C and adjusted to pH 7 with citric acid or acetic acid should be used for sanitization.

• Processors should be trained in all processing steps, the importance of sanitation protocols, waste disposal, personal hygiene, packaging and bottling procedures.

**Retail marketing (CLP#4)**

Only mangoes that are physiologically mature must be harvested for the ripe table fruit market. The best temperature for ripening mangoes is 20 to 22 °C at 90 to 95 percent relative humidity to prevent excessive water loss and shrivelling. Mangoes that have begun to ripen can be recognized by a change in the skin ground colour from green to yellowish green and by the development of yellow colour in the flesh near the seed. Fruit harvested at this stage of maturity are capable of ripening to completion without added ethylene being required.

To capitalize on market demands it would be necessary to enhance the ripening process. This is achieved by treating fruit with 100 ppm ethylene at 20–22 °C. A well-controlled ripening procedure produces mangoes that possess uniformly good eating quality and allows retailers to offer consumers mangoes that are ready to eat.

Adequate air movement is recommended for mangoes in cartoons and relative humidity should be maintained at 90–95 percent.

A regular cleaning and sanitation programme should be implemented to maintain quality and attractive display of fruits. Rotate the mango display frequently to remove damaged, shrivelled and over ripe fruit. Display mangoes according to size, ripeness stage and cultivar. Prior to placing ripe mangoes on the retail display, the fruit should be treated to minimize decay causing organisms. This could be either a hot water treatment or a fungicidal or bactericidal treatment. Imazalil is a recommended fungicide that could be mixed in hot water to control anthracnose and stem end rot. Prochloraz (250–800 ppm for 15 seconds is also recommended to control anthracnose. Heat treatment is also recommended for disease control and insect disinfestations.

These heat treatments are carried out at temperatures of 48 to 55 °C for 3 to 15 minutes depending on cultivar and the extent of the problem. Heat treatments should be applied immediately after receiving and washing of the fruit at the packinghouse. Hot water is recommended to control anthracnose and stem end rot. However, shorter treatments are recommended for anthracnose (3 minutes), while stem end rot usually needs 7 minutes or more. To avoid chilling injury mangoes should not be stored below 12 °C.

Training to demonstrate treatments for microbial control, hot water treatments, ethylene management, low temperature storage, sizing and grading, display procedures and safe low temperature storage regimes supplemented with modified atmosphere packaging techniques should be implemented.

**Investment programme to reduce food losses**

Post-harvest losses of fresh table ripe mangoes were higher at CLP#3 and CLP#4. The cv. Buxton Spice is used for both fresh and processed fruit. For the fresh fruit at CLP#1 the weighted post-harvest losses were 17.5 percent and at CLP#4 post-harvest losses were 4.3 percent. For processed kuchelar the weighted post-harvest loss measured at CLP#2 was 2.9 percent and for frozen mango slices at CLP#3 it was 3.2 percent. Thus the total post-harvest losses for mango in Guyana amounted to 28 percent (Table 5.6). Based on 2012 annual production of 1,499 tonnes of mangoes/year at USD 1,880/tonne, annual production is estimated at USD 2,818,120 (Table 5.6). The percentage loss at each CLP level is then used to estimate the economic loss. Table 5.6 also shows that at CLP#1 the loss is an estimated USD 422,720 and at CLP#4 the loss is USD 479,000 respectively. The economic loss calculated was derived from the data obtained from regions covered under the study, therefore these are estimates and should not be taken as official national statistics.

Table 5.7 shows the corresponding magnitude of loss for each CLP, and the suggested interventions to reduce the losses. Investments for loss reduction identified in Table 5.7.
## TABLE 5.6
Economic loss associated with respective critical loss points – Mango, Guyana

<table>
<thead>
<tr>
<th>Critical Loss Point</th>
<th>Magnitude of Losses % (weighted)</th>
<th>Value of Annual Production (USD)</th>
<th>Economic Loss (USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field harvest CLP#1</td>
<td>17.5</td>
<td>2,818,120</td>
<td>493,171</td>
</tr>
<tr>
<td>Making kuchelar CLP#2</td>
<td>2.9</td>
<td>2,818,120</td>
<td>81,725.48</td>
</tr>
<tr>
<td>Making frozen slices CLP#3</td>
<td>3.2</td>
<td>2,818,120</td>
<td>90,178.84</td>
</tr>
<tr>
<td>CLP#4</td>
<td>4.3</td>
<td>2,818,120</td>
<td>121,179.2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>28</strong></td>
<td><strong>2,818,120</strong></td>
<td><strong>786,255.5</strong></td>
</tr>
</tbody>
</table>

USD 1.00 = GYD 200
Note: Based on 1,499 tonnes/year (2012) @ GYD 376/kg or GYD 376,000/tonne (USD 1,880/tonne)

## TABLE 5.7
Summary table of food losses, causes and solutions – Guyana

<table>
<thead>
<tr>
<th>Critical Loss Point</th>
<th>Magnitude of losses % (Weighted)</th>
<th>Economic Loss (USD)</th>
<th>Cause of loss</th>
<th>Intervention to reduce losses</th>
<th>Loss reduction</th>
<th>Cost of intervention</th>
<th>Risks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field harvest CLP#1</td>
<td>Fresh Mango - (17.5)</td>
<td>493,171</td>
<td>Cuts, bruises, punctures, abrasions, stem end damage, latex stains, exposure to high temperature</td>
<td>Correct maturity at harvest, trained harvesters, harvesting rods, shallow plastic crates, latex stain avoidance, high temperature avoidance, precooling, training</td>
<td>Commercial, economic</td>
<td>Cost of equipment = USD 300; training = USD 6,000 Plastic crates = USD 60/crate</td>
<td>No perceivable risks</td>
</tr>
<tr>
<td>Kuchelar CLP#2</td>
<td>Achar (Kutchelar) – (2.9)</td>
<td>81,725.48</td>
<td>Failure to sort at point of receipt, wounds at harvest, over ripe fruits, over packing of harvest bags, poor ventilation of bags, exposure to high temperatures</td>
<td>At point of receipt from suppliers standard quality protocols to be adhered, mature green fruits with no physical damage, sorting, latex removal, use of plastic crates, food processor, precooling and temperature management, training</td>
<td>Same</td>
<td>Grading tables, stainless steel cutting knives and utensils, dehydrators, bottles = USD 5,000; training = USD 4,000 Food processor = USD 600</td>
<td>No perceivable risks</td>
</tr>
<tr>
<td>Frozen slices CLP#3</td>
<td>Frozen mango slices – (3.2)</td>
<td>90,178.84</td>
<td>Failure to sort at point of receipt, wounds at harvest, over ripe fruits, over packing of harvest bags, poor ventilation of bags, exposure to high temperatures</td>
<td>At point of receipt from suppliers standard quality protocols to be adhered, mature green fruits with no physical damage, sorting, latex removal, use of plastic crates, precooling and temperature</td>
<td>Same</td>
<td>Electric sealer = USD 400; freezer = USD 1,000, packaging supplies = USD 400, training = USD 4,000</td>
<td>No perceivable risks</td>
</tr>
<tr>
<td>Retail Marketing CLP#4</td>
<td>Fresh ripe mango – (4.3)</td>
<td>121,179.2</td>
<td>Exposure to high temperatures, failure to sort and grade, poor sanitary conditions in ripening room, inadequate ripening conditions</td>
<td>Ripening facility to store fruits in air-conditioned room equipped with humidifier, hot water treatment facility, fungicidal dip to control decay</td>
<td>Same</td>
<td>Ripening room with temperature and relative humidity control = USD 4,200, hot water treatment facility = USD 3,000; fungicides and sanitizers = USD 500</td>
<td>No perceivable risks</td>
</tr>
</tbody>
</table>
Cost benefit analysis of the proposed solutions

A mango picking rod is recommended for use in Guyana, based on a 5-acre production base, Table 5.8 shows the profitability of using a mango picking rod as USD 3,650.80.

Mango ripening room

In Guyana, it is assumed that the selling price is USD 1,880/tonne. Based on these assumptions, profitability of using a ripening room for mangoes is calculated at USD 252.69 (Table 5.9).

<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>Unit</th>
<th>Calculation Formula</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Product quantity</td>
<td>tonnes/year</td>
<td></td>
<td>18.9</td>
</tr>
<tr>
<td>b</td>
<td>Product value</td>
<td>USD/tonne</td>
<td></td>
<td>1,880</td>
</tr>
<tr>
<td>c</td>
<td>Loss rate</td>
<td>%</td>
<td></td>
<td>0.175</td>
</tr>
<tr>
<td>d</td>
<td>Anticipated loss reduction</td>
<td>%</td>
<td></td>
<td>0.6</td>
</tr>
<tr>
<td>e</td>
<td>Cost of intervention (picking rod)</td>
<td>USD</td>
<td></td>
<td>300</td>
</tr>
<tr>
<td>f</td>
<td>Depreciation</td>
<td>years</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>g</td>
<td>Yearly costs of investment</td>
<td>USD/year</td>
<td>e / f</td>
<td>60</td>
</tr>
<tr>
<td>h</td>
<td>Yearly costs of operation</td>
<td>USD/year</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>i</td>
<td>Total yearly costs of solution</td>
<td>USD/year</td>
<td>g + h</td>
<td>80</td>
</tr>
<tr>
<td>j</td>
<td>Client costs per tonne product</td>
<td>USD/tonne</td>
<td>i / a</td>
<td>4.23</td>
</tr>
<tr>
<td>k</td>
<td>Food loss</td>
<td>tonnes/year</td>
<td>c x a</td>
<td>3.31</td>
</tr>
<tr>
<td>l</td>
<td>Economic loss</td>
<td>USD/year</td>
<td>k x b</td>
<td>6,218.1</td>
</tr>
<tr>
<td>m</td>
<td>Loss reduction</td>
<td>tonnes/year</td>
<td>k x d</td>
<td>1.98</td>
</tr>
<tr>
<td>n</td>
<td>Loss reduction savings</td>
<td>USD/year</td>
<td>m x b</td>
<td>3,730.86</td>
</tr>
<tr>
<td>o</td>
<td>Total Client costs</td>
<td>USD/year</td>
<td>i = a x j</td>
<td>80</td>
</tr>
<tr>
<td>p</td>
<td>Profitability of solution</td>
<td>USD/year</td>
<td>n - o</td>
<td>3,650.80</td>
</tr>
</tbody>
</table>
**Table 5.9**  
Profitability of using a ripening room for 5 acres of mangoes in Guyana

<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>Unit</th>
<th>Calculation Formula</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Product quantity</td>
<td>tonnes/year</td>
<td></td>
<td>18.9</td>
</tr>
<tr>
<td>b</td>
<td>Product value</td>
<td>USD/tonne</td>
<td></td>
<td>1880</td>
</tr>
<tr>
<td>c</td>
<td>Loss rate</td>
<td>%</td>
<td></td>
<td>0.043</td>
</tr>
<tr>
<td>d</td>
<td>Anticipated loss reduction</td>
<td>%</td>
<td></td>
<td>0.75</td>
</tr>
<tr>
<td>e</td>
<td>Cost of intervention (ripening room)</td>
<td>USD</td>
<td></td>
<td>3000</td>
</tr>
<tr>
<td>f</td>
<td>Depreciation</td>
<td>years</td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>g</td>
<td>Yearly costs of investment</td>
<td>USD/year</td>
<td>e / f</td>
<td>200</td>
</tr>
<tr>
<td>h</td>
<td>Yearly costs of operation</td>
<td>USD/year</td>
<td></td>
<td>500</td>
</tr>
<tr>
<td>i</td>
<td>Total yearly costs of solution</td>
<td>USD/year</td>
<td>g + h</td>
<td>700</td>
</tr>
<tr>
<td>j</td>
<td>Client costs per lb product</td>
<td>USD/tonne</td>
<td>i / a</td>
<td>37.04</td>
</tr>
<tr>
<td>k</td>
<td>Food loss</td>
<td>tonnes/year</td>
<td>c x a</td>
<td>0.81</td>
</tr>
<tr>
<td>l</td>
<td>Economic loss</td>
<td>USD/year</td>
<td>k x b</td>
<td>1270.25</td>
</tr>
<tr>
<td>m</td>
<td>Loss reduction</td>
<td>tonnes/year</td>
<td>k x d</td>
<td>0.61</td>
</tr>
<tr>
<td>n</td>
<td>Loss reduction savings</td>
<td>USD/year</td>
<td>m x b</td>
<td>952.69</td>
</tr>
<tr>
<td>o</td>
<td>Total Client costs</td>
<td>USD/year</td>
<td>i = a x j</td>
<td>700</td>
</tr>
<tr>
<td>p</td>
<td>Profitability of solution</td>
<td>USD/year</td>
<td>n - o</td>
<td>252.69</td>
</tr>
</tbody>
</table>
Bibliography


CARICOM View. 2011. Food Security in CARICOM.


Craig, Kelvin. 2007. Study of marketing opportunities for small non-traditional crop farmers. Social Entrepreneurship Program, CHF/Partners in Rural Development.

Evans, E.A. 2008. Recent trends in world and US mango production, trade, and consumption. EDIS #FE718, UF/IFAS Extension, Gainesville, FL.


USDA-ERS. 2010. *Food Availability (Per Capita) Data System.*

